ORIGINAL ARTICLE

Clinical Improvement Following Home Parenteral Nutrition in Pediatric Patients with Intestinal Failure

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Background/Purpose: Home parenteral nutrition (HPN) is being increasingly used to treat children with intestinal failure. This study evaluated the long-term growth, outcome and complications in Taiwanese pediatric patients with intestinal failure who were treated with HPN.

Methods: This retrospective study included 27 consecutive pediatric patients with intestinal failure who received long-term HPN between 1987 and 2002. These patients were categorized into two groups according to whether they had short bowel syndrome or a bowel motility disorder. Growth, prognosis and complications, including cholestasis, hypoglycemia, hyperglycemia and infections were compared between the two groups.

Results: The median age of starting HPN was significantly younger in patients with short bowel syndrome (5 months) than in patients with motility disorders (1.9 years). The median duration of HPN treatment in the overall group was 13.5 months (range, 2.1–113.1 months); weight and height increased 1.7 ± 2.3 and 1.0 ± 1.6 in z score, respectively. The most common complications were cholestatic liver disease (52%), hypoglycemia (15%) and hyperglycemia (33%). All patients maintained stable serum glucose levels at follow-up. Cholestatic liver disease developed after 2.3 ± 2.0 months of total HPN in 13 patients, which subsided after 9.7 ± 6.9 months in 11 patients, while two patients died. The mean incidence of central venous infection was 3.0 ± 3.3 per 1000 HPN days. The most common pathogens were *Staphylococcus* spp. (50%) and *Candida* spp. (30.6%).

Conclusion: HPN treatment can successfully provide a bridge to enteral nutrition in pediatric patients with intestinal failure. The metabolic disturbances and cholestasis are usually transient, but infection control is important throughout the period of HPN treatment. [*J Formos Med Assoc* 2006;105(5):399–403]

Key Words: bacteremia, bowel motility disorder, cholestatic liver disease, home parenteral nutrition, short bowel syndrome

Intestinal failure is defined as the reduction in functioning gut mass below the amount necessary for adequate digestion and absorption of food.[1] Total or partial parenteral nutrition (TPN, PPN) via a central venous catheter is required in these patients to maintain or obtain adequate growth. The home parenteral nutrition (HPN) technique was developed as an effective and feasible nutrition supply route for those who require long-term TPN.[2] In children with intestinal failure, HPN can aid in the transition from TPN to enteral feeding.[3–5] Encouragement of enteral nutrition is very important to enhance intestinal adaptation and to avoid irreversible gut failure.[6] In patients with persistent intestinal failure, however, long-term HPN may be needed until a good pro-

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gram of small bowel transplantation is available. The purpose of this study was to evaluate the prognosis, complications and duration of intestinal adaptation after HPN treatment.

Methods

The Total Parenteral Nutrition Support Team of this hospital was established in 1987 to care for patients receiving HPN support. Before implementation of this program, parenteral nutrition required a prolonged hospital stay. There were 33 pediatric patients who received TPN support via central venous infusion at home between 1987 and 2002. Among them, six patients received HPN for less than 2 months and were excluded from this study. The characteristics of the remaining 27 patients are shown in Table 1. A complete HPN program started from the insertion of either a Hickmann or Broviac central venous catheter for long-term use. The parenteral nutrition solution contained glucose, amino acids, electrolytes and trace minerals. Fat emulsion was administered via a Y set with parenteral fluid. These patients received continuous total or partial parenteral fluid infusion with a constant infusion volume and composition initially, tapered to 10–12 hours infusion per day before discharge. Serum electrolytes, plasma glucose and liver enzyme activity were monitored regularly. Before discharge from hospital, the patients and their caregivers were trained in the use of aseptic procedures and HPN technique. The use of the HPN program was also monitored at regular outpatient follow-ups.

Patients were divided into the short bowel syndrome group or the bowel motility disorder group according to their underlying disease. Cholestasis was defined as a serum total bilirubin level > 2 mg/dL with a pattern of conjugated hyperbilirubinemia. Two patients with cholestasis before HPN treatment were excluded from the evaluation for the complication of cholestatic liver disease. Fasting serum glucose level > 126 mg/dL (7 mmol/L) was defined as hyperglycemia, and < 50 mg/dL was defined as hypoglycemia.

Table 1. Diagnoses in pediatric patients receiving HPN

Diagnosis	*n* (%)
Short bowel syndrome	13 (48)
Congenital	4
Necrotizing enterocolitis	3
Gastroschisis	3
Tumor s/p operation	2
Atresia s/p resection	1
Bowel motility disorder	14 (52)
Malrotation*	1
Multiple atresia*	1
Diaphragmatic hernia†	1
Tumor‡	2
Hirschsprung disease§	1
Neuronal dysplasia	1
Motility disorder	4
Eosinophilic enteropathy	1
Crohn's disease	2

**Malrotation/multiple ileal atresia status after operation, with poor wound healing and motility disorder; †diaphragmatic hernia status after operation, complicated with ileus and fistula; ‡neuroblastoma and gastric cancer with intestinal obstruction; §patient had symptoms of severe diarrhea postoperatively and regained enteral nutrition within 1 year.*

Statistical analysis

The age at starting HPN, duration of HPN, outcome and complications were compared between patients with short bowel syndrome and patients with motility disorders. Data were expressed as mean ± standard deviation or median (range). Statistical analysis was performed by the Mann-Whitney U test, and paired data were compared by the Wilcoxon signed rank test. The chi-square test was used for categorical data. A p value < 0.05 was considered to indicate a significant difference, and a p value < 0.1 a trend of difference.

Results

The short bowel syndrome group comprised 13 patients with an anatomically inadequate length of bowel, either congenital or acquired after massive bowel resection. The bowel motility disorder group comprised 14 patients who had an adequate length of bowel anatomically, but had either me-

chanical or functional bowel obstruction (Table 1). The median age at the start of HPN was 5 months (range, 2–13 months) in the short bowel syndrome group, and 1.9 years (range, 4 months to 15.75 years) in the bowel motility disorder group. The median duration of HPN treatment was 13.5 months (range, 2.1–113.1 months), and was not significantly different between the two groups (Table 2).

During follow-up in the short bowel syndrome group, four patients died, three continued to use total or partial HPN, five successfully transitioned to total enteral nutrition, and one was lost to follow-up. In the bowel motility disorder group, two patients died, two continued to use total or partial HPN, nine successfully transitioned to total enteral feeding, and one was lost to follow-up. Of the six patients who died, five died of shock, including three (50%) with bacteremia and two (33.3%) with fever of unknown origin. One patient (16.7%) died of obstructive airway disease without infection. The 14 patients who successfully transitioned to total enteral nutrition discontinued HPN therapy after 17.9 ± 22.3 months of use. Weight increased significantly from –2.8 ± 2.4 to –1.2 ± 1.3 in z score, and height increased from –3.0 ± 3.0 to –2.0 ± 2.3 in z score after HPN treatment.

The most common complications of HPN treatment were infection (63%), hypoglycemia (15%), hyperglycemia (33%) and cholestatic liver disease (52%). There was no association between the incidence of complications and age. The incidence of transient hypoglycemia was significantly higher in patients with short bowel syndrome than in patients with bowel motility disorders. The median age of the four patients with hypoglycemia was 5 months (range, 3–8 months). There were no significant differences in the frequency of other complications between the two groups. Four of the patients with bowel motility disorders had no complications during a median duration of

Table 2. Characteristics of patients and complications during home parenteral nutrition (HPN)

	Short bowel syndrome	Bowel motility disorder	*p*
Patients, *n*	13	14	
Male / Female	9/4	9/5	0.65
Mean age of starting HPN, yr (range)	0.4 (0.2–1.1)	1.9 (4–15.8)	< 0.001*
Mean HPN duration, mo (range)	15.5 (3.4–109.1)	10.7 (2.1–113.1)	0.325
Prognosis, *n*			0.233
Died	4	2	
Continued HPN usage	3	2	
Enteral feeding	5	9	
Lost to follow-up	1	1	
Complications†			
Free from complications	0	4	0.03*
Sepsis	10	7	0.06
Hypoglycemia	4	0	0.01*
Hyperglycemia	3	6	0.16
Cholestasis	8	5	0.05
Sepsis rate (/1000 HPN days)	3.9 ± 4.2	2.1 ± 3.5	0.094
Outcome‡			
Weight gain (z score)	1.4 (–2.6 → –1.2)	1.9 (–3.0 → –1.2)	0.72
Height gain (z score)	1.0 (–2.1 → –1.3)	1.0 (–3.7 → –2.8)	0.72

**p < 0.05; †hypoglycemia was defined as fasting serum glucose < 50 mg/dL, hyperglycemia as fasting serum glucose > 126 mg/dL, and cholestasis as serum total bilirubin > 2 mg/dL; ‡weight and height before and after HPN treatment expressed in z score for age in parentheses.*

HPN use of 6.2 months (range, 3.1–12.1 months). All patients maintained stable serum glucose levels before discharge from hospital. Cholestatic liver disease developed after HPN treatment in 13 patients. Among them, 11 patients recovered, but two died from sepsis and airway obstruction after using HPN for 8 months and 1 year and 2 months, respectively. Cholestatic liver disease developed at 2.3 ± 2.0 months after starting TPN, and recovery occurred at 9.7 ± 6.9 months of use.

During a follow-up of 52.8 person-years of HPN usage, 83 catheters were inserted in the 27 patients. Sixty-nine catheters were removed in hospital. Eight catheters were removed due to HPN discontinuation, and 61 were removed due to infection (66%), occlusion (10%), leakage (3%) and dislodgement (21%), as summarized in Table 3. Microbacterial infection was found in 34 catheters, and 27 of them were removed. The mean incidence of central venous infection was 3.0 ± 3.9 per 1000 HPN days. The most common pathogens isolated in patients with bacteremia were *Staphylococcus* spp. (50%) and *Candida* spp. (30.6%), as shown in Table 4.

Table 3. Reasons for catheter removal in pediatric patients receiving home parenteral nutrition

Reasons	Catheters removed, *n*
Infection	40
Proven sepsis	26
Local infection	1
Fever or suspected sepsis	13
Persistent occlusion	6
Catheter dislodgement	13
Catheter leakage	2
Catheter no longer needed	8

A total of 69 catheters were removed in 27 patients.

Table 4. Etiology of bacteremia in pediatric patients receiving home parenteral nutrition

Organism	Positive cultures, *n*
Staphylococcus spp.	18
Staphylococcus aureus	9
Staphylococcus epidermidis	6
Staphylococcus hominis	3
Gram-negative bacilli	7
Klebsiella pneumoniae	1
Escherichia coli	2
Acinetobacter spp.	2
Stenotrophomonas maltophilia	1
Corynebacterium spp.	1
Fungi	11
Candida parapsilosis	4
Candida guilliermondii	3
Candida albicans	3
Candida tropicalis	1

Thirty-six microorganisms were cultured in 34 catheters in 52.8 person-years; mixed infection was found in five catheters (4 catheters in the same patient).

Discussion

Patients with short bowel syndrome comprise the majority of patients who receive HPN treatment, especially among children.[6,7] The underlying causes of short bowel syndrome are different in children and adults. Congenital short bowel or acquired short bowel due to necrotizing enterocolitis, gastroschisis or atresia accounted for about half of the patients who received HPN in this series. The age at HPN treatment was significantly younger in patients with short bowel syndrome. The prognosis and incidence of complications, however, was not different between the short bowel syndrome group and the bowel motility disorder group, except for hypoglycemia, which was associated with younger age in the short bowel syndrome group. The body weight and height of patients in both groups significantly improved after HPN treatment, especially body weight which increased by 1.7 in z score. HPN is the better choice for adequate nutritional support in patients with intestinal failure. Infants and children have greater potential for intestinal adaptation, which usually occurs within 3–12 months and even up to 3 years.[8,9] In this study, 14 patients (52%) could achieve total enteral nutrition after 17.9 ± 22.3 months of HPN. This finding indicates that HPN is a successful method for bridging to

enteral nutrition in the majority of pediatric patients with intestinal failure.

As long-term HPN support is necessary in some patients with persistent intestinal failure, avoiding HPN-related complications becomes an even more important issue.[10] Catheter infection and mechanical complications can be eliminated if caregivers are familiar with aseptic procedures. The infection rate in this pediatric series of 3.0 per 1000 HPN days is higher than in a previous study in adults of 2.1 per 1000 HPN days.[11] A lower incidence of infection was reported to be associated with longer HPN duration and the delay between HPN onset and the first infection.[12–14] The failure to identify any factors associated with infection in this study may have been due to the shorter duration of HPN use in children than in adults, with many children successfully transitioning to enteral nutrition in the first 2 years. The incidence of infection can be decreased further through a good aseptic program for HPN.

Transient hypoglycemia was observed in four patients in this series, all of whom were younger than 8 months. This observation indicates the importance of blood glucose monitoring in infants and younger children receiving HPN. The prevalence of chronic cholestasis or complicated HPN-related liver disease increased with longer duration of parenteral nutrition, which was reported in adult patients.[15] In this study, 52% of pediatric patients developed cholestatic liver disease after a mean duration of 2.3 months of HPN treatment, but all recovered. This finding suggests the high potential of children to develop and recover from liver dysfunction during HPN.

In conclusion, HPN treatment can allow pediatric patients with intestinal failure to achieve adequate weight and height gain, and is a successful and temporary method to regain enteral nutrition in patients with intestinal adaptation. The metabolic disturbances are mostly transient, and, although cholestatic liver disease frequently develops, almost all children recover. Bacteremia is a relatively common problem, and prevention of sepsis is important throughout the period of HPN treatment.

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